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CRETACEOUS DEPOSITS AND THE ILLINOIAN GLACIAL BOUNDARY IN WESTERN ILLINOIS

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ABSTRACT

In Adams and Pike Counties of extreme western Illinois, the Baylis Formation of Cretaceous age underlies an area of 80 to 100 square miles and attains a maximum thickness of approximately 100 feet. The Baylis Formation consists of two members: the Hadley Gravel Member at the base previously has been referred to a Tertiary age; the overlying Kiser Creek Member, consisting of sand and clay, previously has been included in the Pleistocene. The Baylis Formation is assigned to a Cretaceous age because of (1) the striking similarity of its heavy mineral suite to that in Cretaceous deposits in Iowa, Minnesota, Wisconsin, and Kansas, and the strong contrast with heavy mineral assemblages from the Pleistocene and Paleozoic deposits of the region; (2) the similarity of the clay mineral compositions with those of known Cretaceous deposits and their contrast with those of Pleistocene and Paleozoic rocks; (3) the rock types present in the basal gravels; (4) its stratigraphic relations; and (5) its general lithologic similarities to Cretaceous deposits to the northwest and west. The Baylis Formation appears to rest on a generally planate surface that slopes northwestward from about 800 feet, northwest of Pittsfield, to about 670 feet, northeast of Quincy. The Baylis Formation comprises a prominent interstream ridge for about 15 miles northwest of Pittsfield, formerly regarded as an Illinoian glacial moraine. A study of the heavy minerals and clay minerals of the tills and outwash in the area, together with field relations, shows that the limit of Illinoian glaciation is more than 15 miles northeast of the formerly mapped position. Illinoian till does not occur at Payson, and the name Payson Substage previously used for the earliest Illinoian Substage is no longer appropriate. The name Liman Substage is proposed as a replacement.

INTRODUCTION

To provide data on the mineral composition of the surficial materials of Illinois for use by engineering geologists, ceramists, and soil scientists and to aid in stratigraphic identification and correlation of these deposits, the Illinois State Geological Survey has been studying the near-surface materials in all parts of the state. During 1963, field studies and sampling were carried on in extreme western Illinois. It was found that extensive deposits formerly called Pleistocene and Tertiary are more properly classed as Cretaceous and that Illinoian drift is absent in a large area where it previously was mapped. This report gives the results of field and laboratory investigations, describes the character, extent, and composition of the Cretaceous deposits, and shows the remapped limit of Illinoian glaciation in the area.

The potential economic uses of the Cretaceous deposits have not been investigated fully. The deposits include relatively clean white sands, quartz sands intermixed with kaolinitic clays, montmorillonitic silty clays, and kaolinitic silty clays. Further studies may reveal important commercial uses for these materials in the ceramics and molding sand industries.

The report is concerned with two major items. First, the stratigraphy of a sequence of sand, clay, and gravel that underlies glacial deposits and overlies Pennsylvanian and Mississippian rocks and is here assigned to the Cretaceous. These deposits extend the area of Cretaceous deposition about 200 miles east of the previous limit in western Iowa. In addition, their presence raises questions about the age of the upland erosion surfaces and of other isolated deposits of similar character. The second item is the need for revision of the Pleistocene stratigraphy and mapping. The Illinoian glacial boundary was found to be more than 15 miles northeast from its formerly mapped position.

The area studied, primarily in Adams and Pike Counties, is shown in figure 1. The map shows Cretaceous deposits in an area of 80 to 100 square miles, 59 localities where samples were collected, the locations of 8 measured sections included in this report, and the revised position of the Illinoian glacial boundary. The location and stratigraphic position of all samples used are given in table 1 at the end of the report.

It was impractical to study all size fractions, and mineral analyses were made of one fraction of sand (62-250 microns) and of clay (less than 2 microns). This sand fraction was selected because it had been used in previous studies of Pleistocene deposits throughout Illinois (Frye, Willman, and Glass, 1960; Frye, Glass, and Willman, 1962; Willman, Glass, and Frye, 1963) and is the coarsest size that is common to most samples throughout the range of materials under consideration. In this sand fraction, both the heavy and light minerals were indentified using the optical microscope. The samples of sand were acid treated, sieved, and heavy minerals separated from the 62-250 micron fraction using bromoform. The heavy and light fractions were mounted separately in balsam on slides and the percentages determined by counting 200 grains. Light and heavy mineral analyses are given in table 2 and are summarized in table 4.

Clay minerals in the less than 2 micron fraction were identified by X-ray diffraction from mechanically disaggregated but chemically untreated samples using oriented-aggregate techniques with sodium hexametaphosphate as the dispersing agent. Montmorillonite, illite, chlorite, and kaolinite were calculated. Determination of carbonate minerals was made by X-ray diffraction analysis of finely ground bulk samples and reflects the composition of the combined sand, silt, and clay sizes.

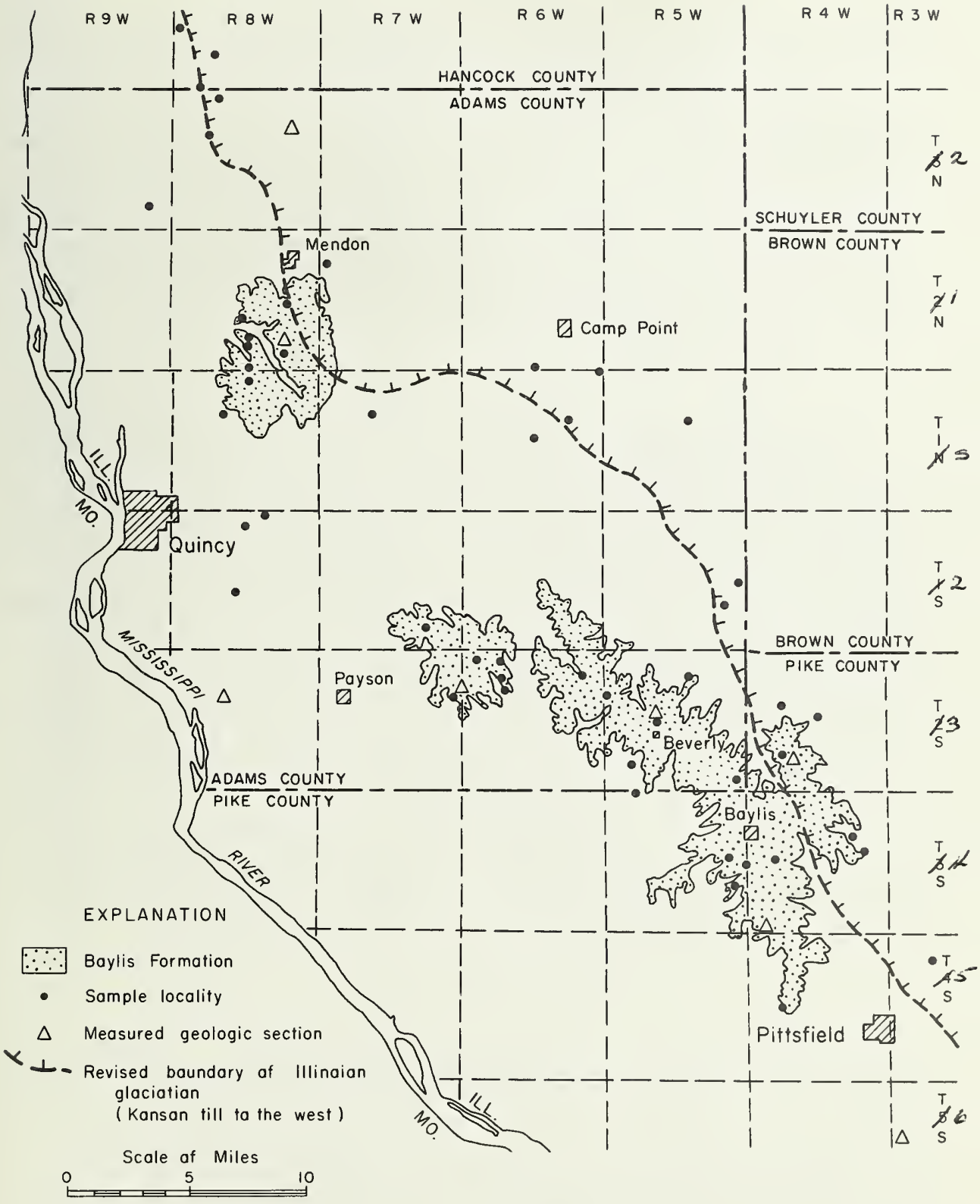

Figure 1 - Map showing the distribution of the Baylis Formation of Cretaceous age in western Illinois, the boundary of Illinoian glaciation, and the locations of samples and geologic sections.

Data are expressed as X-ray counts per second, which indicate semiquantitatively the amount of calcite and dolomite. Carbonate and clay mineral X-ray analyses are given in tables 3 and 5, and smoothed X-ray diffraction traces are shown in figures 2-6.

The heavy and light mineral analyses were made in the Survey laboratories by Constantine Manos, James Bloom, and Richard Mast. X-ray analyses were made by Glass. The problems were discussed in the field with Paul R. Shaffer and Andrew H. Merritt of the University of Illinois and George E. Ekblaw of the Illinois State Geological Survey. Russel A. Peppers of the Geological Survey examined 24 samples of Baylis Formation and 5 samples of Dakota Formation from Guthrie County, Iowa, in an unsuccessful attempt to discover identifiable plant materials. He also examined several samples of Pleistocene material from the area, some of which yielded identifiable plant remains. Estella B. Leopold and R. M. Kosanke of the U. S. Geological Survey examined material from one of these localities.

CRETACEOUS SYSTEM

The surficial deposits of Adams and Pike Counties have not been described since the early work of Leverett (1899, p. 58-64). In his report Leverett described some of the deposits, classed here as Baylis Formation, and suggested that they were pre-glacial but did not assign them a more precise age. Subsequently, Willman suggested that some of the gravels of the area might be Cretaceous in age (Frye, 1963). Other workers have included these materials as part of the sequence of Pleistocene and Tertiary deposits in the region (Salisbury, 1892; Cox, 1929; Horberg, 1950; 1956; Rubey, 1952; Leighton and Brophy, 1961). On the basis of evidence presented here, we have assigned these deposits to the Cretaceous System even though no Cretaceous fossils have been found. The nearest areas of Cretaceous rocks are in Minnesota (Stauffer and Thiel, 1941; Andrews, 1958; Pierce, 1961), in western Iowa (St. John, 1870; Tester, 1931; Andrews, 1958), and in southern Illinois (Pryor, 1960; Pryor and Ross, 1962; Ross, 1963). Because this area is geographically isolated from the other areas of known Cretaceous deposits, local names are applied to the rock-stratigraphic units.

All of the Cretaceous deposits of the region are included within the Baylis Formation, which is subdivided into two members—the Hadley Gravel Member, at the base, and the Kiser Creek Member, consisting of sand, silt, and clay and comprising the upper and larger part of the formation. The areal distribution of Cretaceous deposits in Adams and Pike Counties is shown on figure 1.

Baylis Formation

The Baylis Formation is named here for the town of Baylis, four miles north of the type section which is the Aberdeen School geologic section ($NW\frac{1}{4}$ $SW\frac{1}{4}$ $SE\frac{1}{4}$ sec. 31, T. 4 S., R. 4 W., Pike County) described in this report. At the type locality, 25 feet of Cretaceous sediments are present overlying shale of the Pennsylvanian Abbott Formation, and an adjacent well penetrated 60 feet of deposits that probably represent the Baylis. This locality is also the type section for the Hadley Gravel Member at the base, named here for the town of Hadley about 4 miles northwest, and the Kiser Creek Member above, named here for the East Branch of Kiser Creek.

The prominent ridge forming the divide between Illinois River and Mississippi River drainage is made by the Baylis Formation. The formation extends northwestward

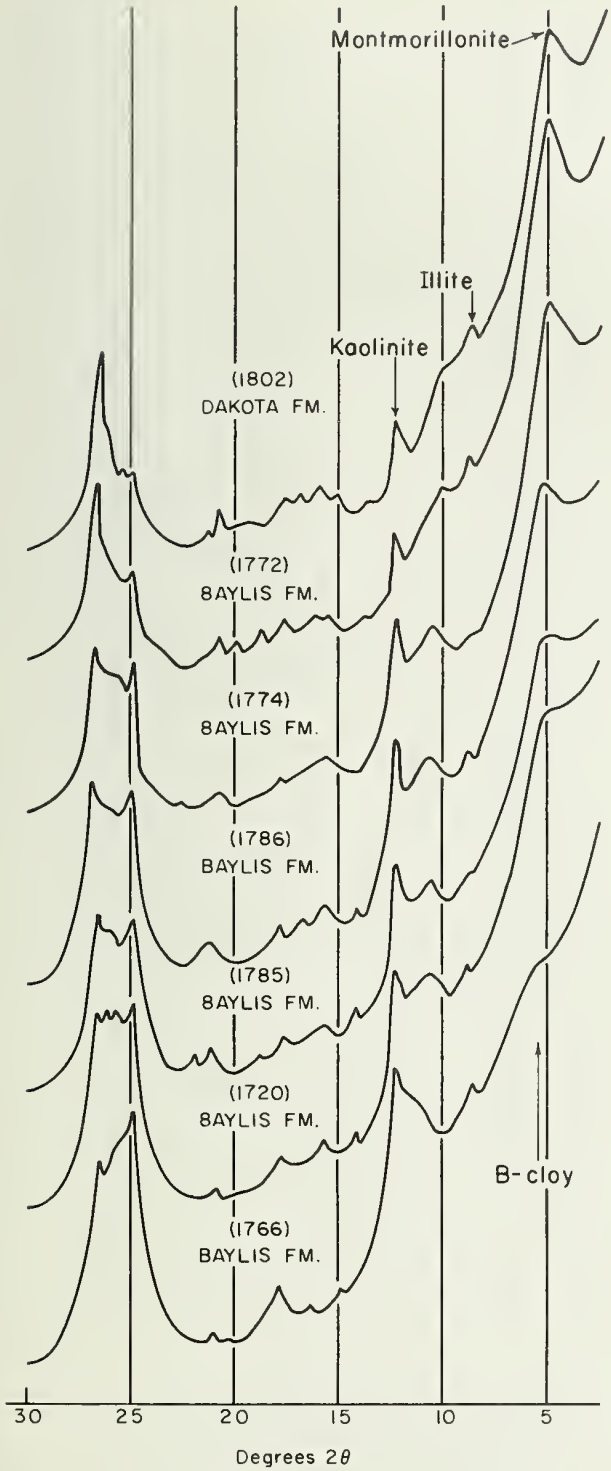

Figure 2 - X-ray diffraction traces from seven samples showing the variation between montmorillonite and B-clay in Cretaceous deposits.

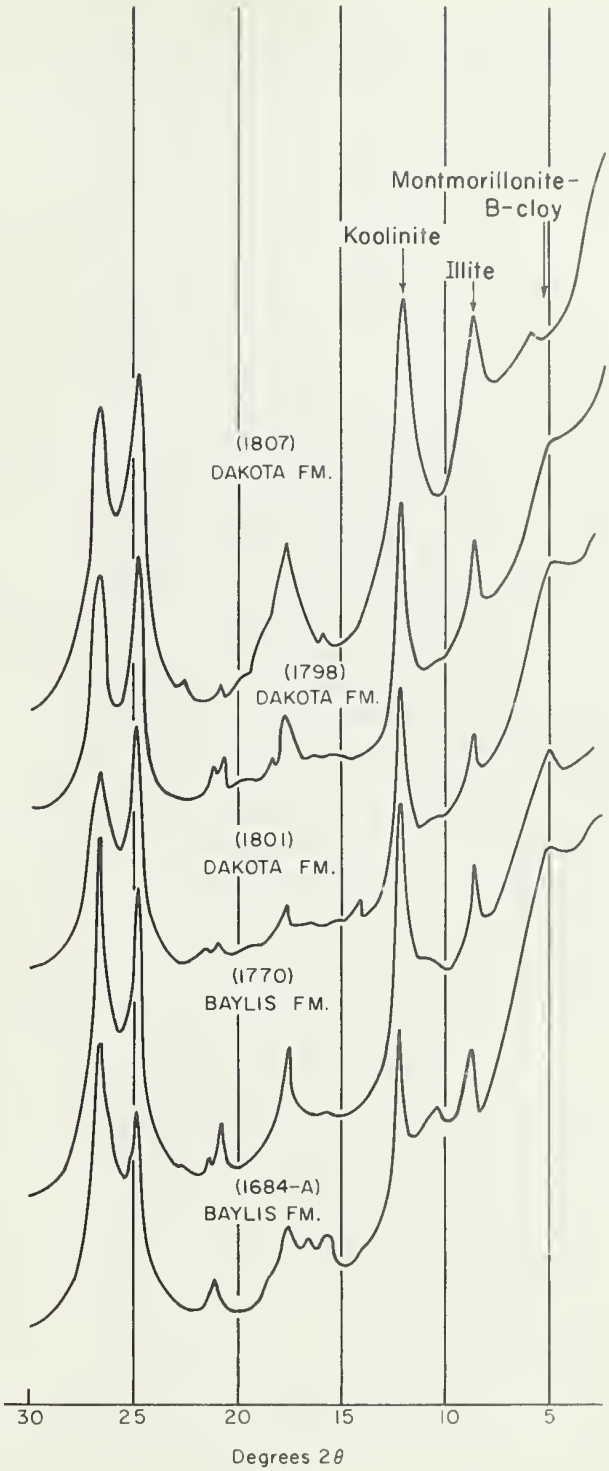

Figure 3 - X-ray diffraction traces from five samples showing high illite-kaolinite content in Cretaceous deposits from Illinois and Iowa.

from a point northwest of Pittsfield nearly 10 miles into Adams County. An isolated smaller area of relatively thin Baylis Formation occurs northeast of Qunicy, where it lacks the distinctive topographic expression of the prominent ridge on which the towns of Baylis and Beverly are located.

The elevation of the basal contact on Pennsylvanian and Mississippian rocks declines generally northwestward from more than 770 feet in the southern part of the area to 670 feet or lower in the area northeast of Qunicy. Because exposures are inadequate, a measurement of maximum thickness has not been made, but the elevations of the basal contact and of the contact above with Wisconsinan loess indicate that the maximum thickness may exceed 100 feet.

From west of Pittsfield, the Baylis-Beverly ridge continues southward with its crest underlain by Mississippian Burlington Limestone mantled by loess. The top of the Burlington Limestone is as high as the top of the Baylis Formation along much of the ridge to the north, but the ridge attains its maximum elevation of 880 feet at the town of Baylis. As the loess generally is 20 feet or less in thickness, the highest elevation attained by the Baylis Formation is about 860 feet.

The Cretaceous sediments owe neither their preservation nor their high topographic position to superior resistance to weathering and erosion. The present distribution of the Cretaceous deposits may be partly the result of (1) the protective influence of the high and resistant limestones to the south, (2) the location of the deposits on a divide, (3) the presence of a slight structural downwarp along the trend of the ridge, corresponding to the sag between the Pittsfield and Fishhook Anticlines, (4) the regional post-Cretaceous downwarping toward the northwest, and (5) the drainage history of the region, which may not have been crossed by the present major rivers until they were diverted by Pleistocene glaciers. Where

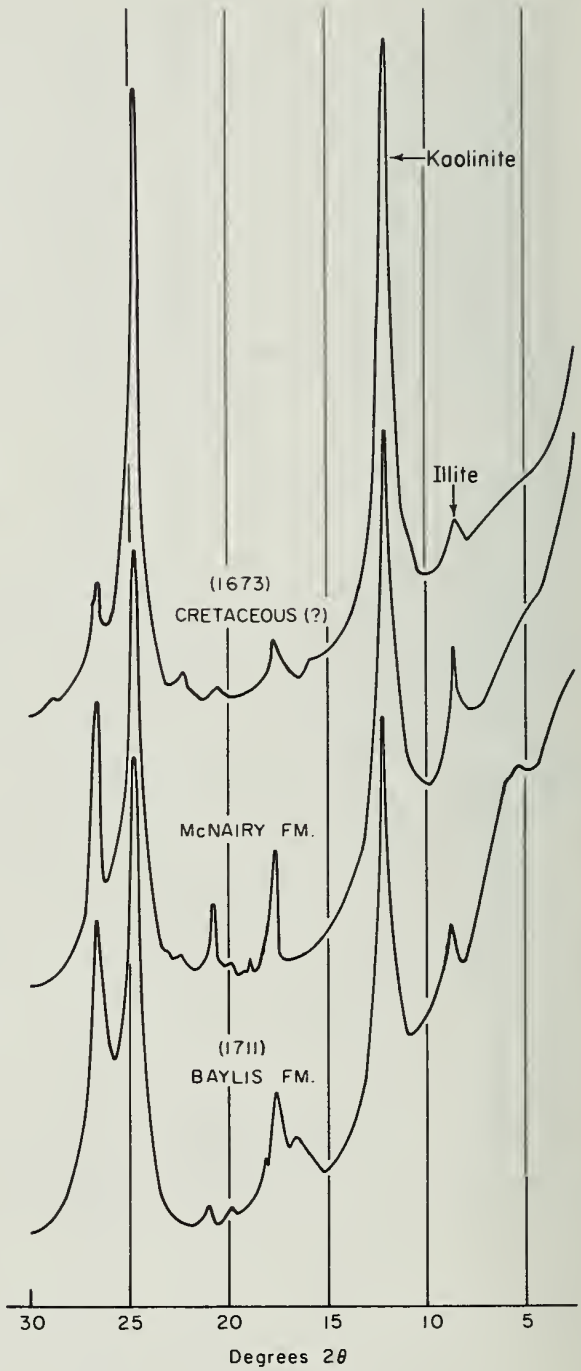

Figure 4 - X-ray diffraction traces from three samples showing the dominance of kaolinite in the McNairy Formation (Cretaceous) of extreme southern Illinois, in local zones in the Baylis Formation (Cretaceous) of western Illinois, and in local deposits that may be Cretaceous in age on the St. Peter Sandstone of northern Illinois.

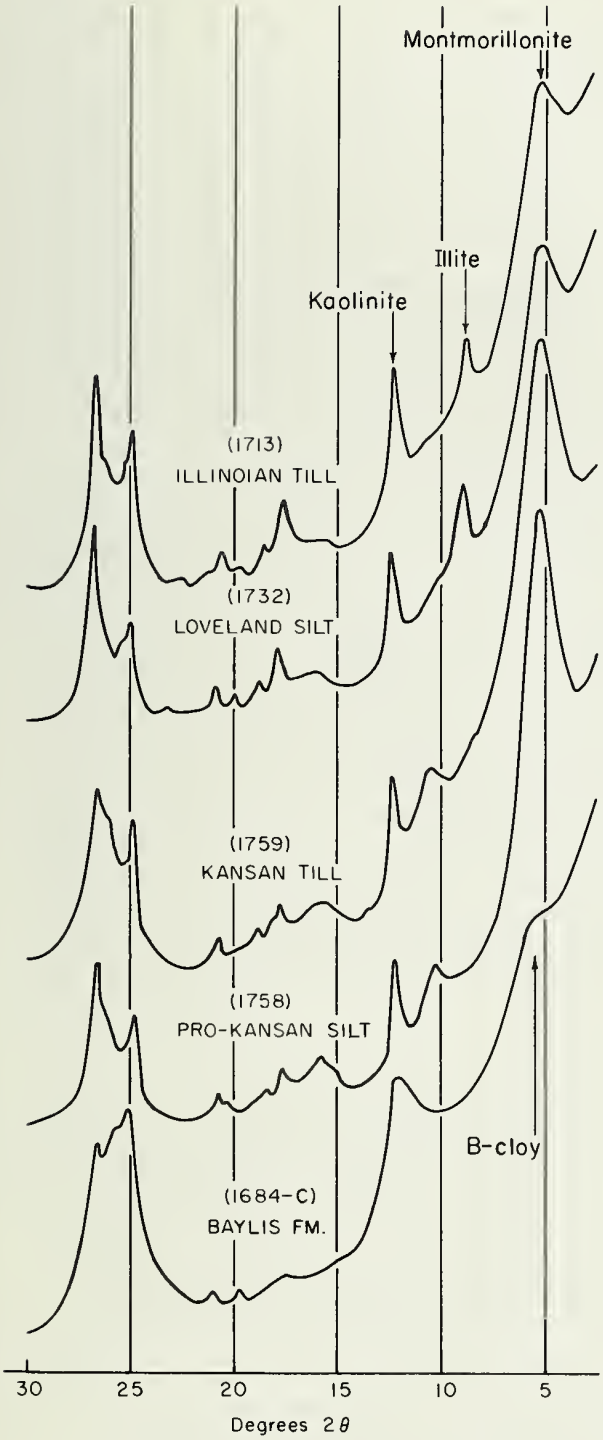

Figure 5 - X-ray diffraction traces from five samples from Adams and Pike Counties, Illinois, showing the differences in composition between the Pleistocene deposits and the Cretaceous Baylis Formation of the region.

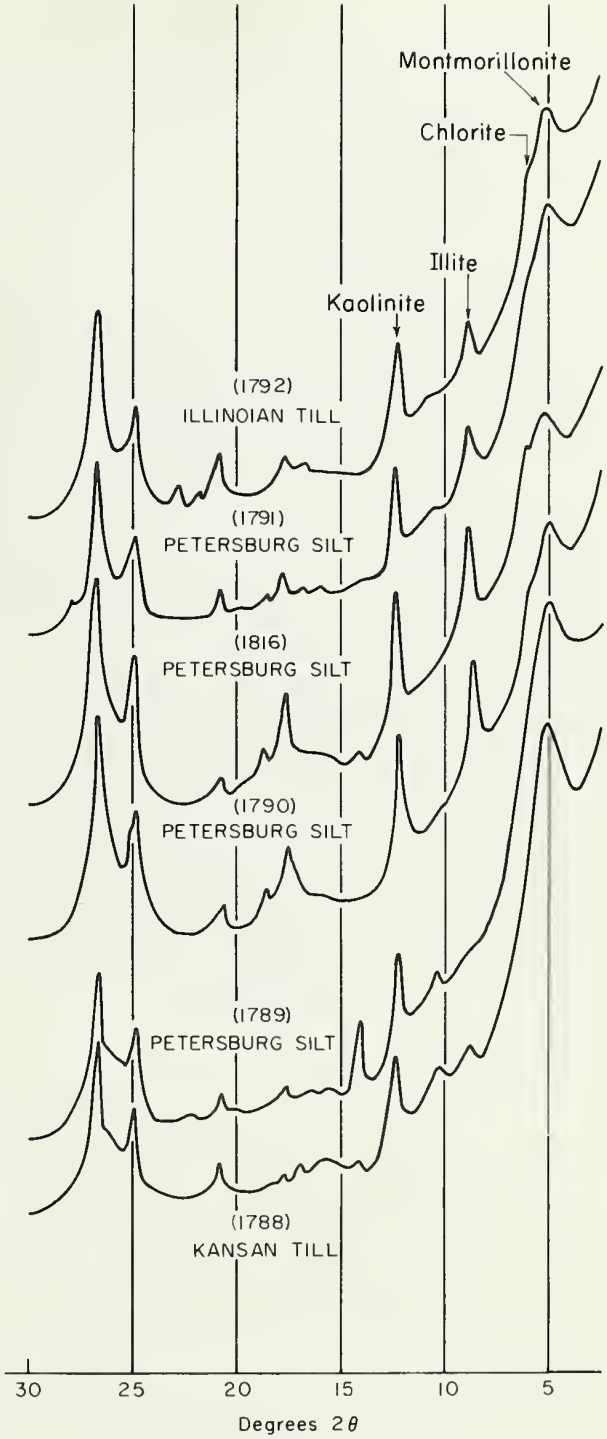

Figure 6 - X-ray diffraction traces from the Pryor School geologic section showing the differences in composition between Kansan and Illinoian deposits.

the soil has been breached, the slopes are subject to gullying and erode at least as rapidly as the glacial deposits of the region.

The Baylis consists predominantly of uncemented fine to medium quartz sand and clayey sand that in some zones contain dispersed granules of angular white chert, in others lenses of silty clay, and at some places moderately well rounded pebbles of chert, quartz, and quartzite. It generally is massive to thick and indistinctly bedded, but in some zones the relatively clean and well sorted medium to fine sands are well bedded and even cross-bedded. The deposits are white to light gray, tan, brown, and orange-brown. The tan and brown commonly occur as color bands and mottling of the gray. Gravel and sand commonly occur at the base. Locally, a few thin zones contain sufficient fine mica, that it can be seen in outcrop. The formation contains no carbonate minerals, glauconite, or igneous rocks. Exposures of the Baylis Formation are neither abundant nor large because the slopes are generally well rounded and mantled by loess and soil.

No indigneous fossils have been recovered so far from the Baylis Formation. Samples were examined in the Survey laboratories for plant spores and pollen and foraminifera. None were found. Although no organic rich beds were observed in the Baylis Formation, it seemed desirable to investigate the possibility that a few spores and pollen could be recovered from the normal sediments. R. A. Peppers made heavy liquid separation in an effort to recover spores or pollen from 24 samples of Baylis Formation collected from widely scattered localities and representing all lithologic types except the gravels. For comparison, he also examined 5 samples from the Dakota Formation of Guthrie County, Iowa. All results were negative.

At one locality in the northern area, abundant spores and pollen were obtained from a thin bed of dark gray sand that occurs as part of the deposits filling a gully cut into the Baylis Formation. The deposits were derived from the adjacent Baylis deposits and superficially resemble them. The fossils from this deposit (samples 1811=1829) are thought to indicate an early Pleistocene age for the gully filling, but other samples (1830-1832) from this same gully fill, however, were barren of identifiable fossils.

Hadley Gravel Member

Gravel and sand that commonly occurs at the base of the Baylis Formation is named the Hadley Gravel Member. The member is described in this report in the Aberdeen School, Beverly, and Rice School geologic sections. Although the member may be as much as 15 feet thick locally, it is generally less than 10 feet thick. At some places, it is represented by a layer of pebbles only a few inches thick. It consists predominantly of pebbles and small cobbles of chert with minor amounts of quartz and quartzite. A count of the 1/4 to $1\frac{1}{2}$ inch pebbles in one exposure gave the following values in percent: white and yellow quartz, 22; pink quartz, 9; gray quartz, 8; pink and gray quartzite, 2; yellow and brown chert, 26; dark gray to black chert, 20; red chert, 10; and oolitic chert, 3. The sand occurring with the gravel is largely quartz.

The base of the Hadley Gravel Member is commonly marked by an iron-cemented zone that ranges up to several inches thick. This zone is black to dark brown in color and is so tightly cemented that the rock breaks through the chert pebbles. X-ray diffraction analyses of the cement show quartz, goethite, and hematite.

Figure 7 - Map showing the present and previous mapping of the limit of Illinoian glaciation in western Illinois. Successive boundaries are shown only where they differ from previous boundaries.

Kiser Creek Member

The bulk of the Baylis Formation occurs above the basal gravel and is classed as the Kiser Creek Member. The member is described in the Aberdeen School, Beverly, Elm Grove School, Rice School, and Woodland School geologic sections. The general description of the formation applies to the Kiser Creek Member.

Mineralogy

A mineralogical approach to the identification of tills deposited by glaciers advancing from different regions has been used in Illinois (Willman, Glass, and Frye, 1963), and the mineralogical distinction between Paleozoic rocks and Pleistocene deposits has long been known. The light mineral fractions of the sand are of minor value because of the general preponderance of quartz and the lack of strong regional variations among the feldspars. In contrast, the heavy mineral fraction, although generally forming less than 1 percent of the deposit, is highly useful because (1) the great diversity of minerals aids in correlation, (2) it indicates source areas in igneous or metamorphic rocks, and (3) the widely varying resistance of these minerals to destruction by weathering makes the fraction indicative of earlier cycles of erosion and sedimentation. Some of the clay minerals are derived directly from the rocks of the source areas, but others reflect the history of alteration in the source of the sediments, during transport, and after deposition.

Heavy Minerals

The average of 10 analyses of heavy minerals from samples of the Baylis Formation shows a dominantly zircon-tourmaline-staurolite suite, with smaller amounts of rutile and kyanite, and minor amounts of garnet, epidote, and hornblende (tables 2 and 4). As shown in table 4, the Baylis heavy mineral suite is like that from the Dakota Formation of western Iowa (Andrews, 1958) and western Minnesota, and the Cretaceous Cheyenne Sandstone of central Kansas (Swineford and Williams, 1945). The Dakota of Iowa and western Minnesota has a somewhat higher percentage of staurolite, whereas the Cheyenne Sandstone is somewhat lower in staurolite.

In striking contrast, the heavy mineral analyses from the younger Kansan and Illinoian deposits of the area (table 4) are characterized by a hornblende-epidote-garnet suite and contain only small amounts of tourmaline, zircon, and staurolite. The Pennsylvanian rocks on which the Baylis rests yield a zircon-tourmaline-rutile suite, with few other heavy minerals.

The Windrow Formation of southeastern Minnesota, regarded as Cretaceous (Andrews, 1958), yields a heavy mineral suite like that in the Baylis Formation, but the Windrow Formation in southwestern Wisconsin differs in having a somewhat lower percentage of tourmaline and a slightly higher percentage of rutile.

South of this region at the head of the Mississippi Embayment, the McNairy Formation of late Cretaceous age has a kyanite-staurolite suite, with significant amounts of tourmaline, zircon, sillimanite, and rutile (table 4). In this southern region, "Lafayette" gravels, generally assigned to the Pliocene, are characterized by a zircon-staurolite-kyanite suite (Potter, 1955) with significant amounts of tourmaline and sillimanite (table 4). The heavy mineral suites of both the McNairy and "Lafayette" differ from the Baylis in having a much higher

content of kyanite and sillimanite and a lower content of tourmaline. Immediately south of Adams and Pike Counties, the Grover Gravel has a zircon-tourmaline suite, with an exceptionally high content of zircon, equalled only in the Pennsylvanian, and a lower percentage of tourmaline and staurolite than the Baylis. The Grover heavy minerals appear to be most like those in the Windrow of southeastern Wisconsin.

To the southeast, the Ohio River Formation of southern Indiana, which occupies a somewhat analogous position and has been assigned to the Paleocene by Wayne (1960), has a tourmaline-zircon-rutile suite and lacks kyanite and staurolite (Pinsak, 1956). This suite most closely matches that in the Pennsylvanian and upper Mississippian sandstones.

TABLE 4 – AVERAGES OF HEAVY MINERAL ANALYSES BY STRATIGRAPHIC UNIT AND BY REGION

			Opaque		Transparent									
Unit	Region	Source	Black	Light	Tourmaline	Zircon	Garnet	Epidote	Rutile	Sillimanite	Kyanite	Staurolite	Hornblende	Others
Windrow	SW. Wisconsin	A	32	40	19	51	T		11		3	16		T
Windrow	SE. Minnesota	B	11	65	39	40	T		10		T	10	1	T
Dakota	W. Minnesota	C	33	38	28	36	3		6		2	25		T
Cheyenne	Cent. Kansas	D	30	36	34	51	1		1			9	T	4
Dakota	W. Iowa	E	15	54	32	32			6		2	28		
Baylis	W. Illinois	F	57	19	31	45	1	1	3		3	14	1	1
Grover	W. Ill.–E. Mo.	G	58	18	19	60	2	5	2		2	5	1	4
Lafayette	Up. Miss. Embay.	H	18	43	11	36	3	2	2	6	16	23		1
McNairy	Up. Miss. Embay.	I			11	8	T	1	6	8	45	15		6
Ohio River	S. Indiana	J			35	35	T		30					
Pennsylv.	W. Illinois	K			22	60	3	T	11	1				3
Kansan	W. Illinois	L	23	19	4	6	11	19	T	T		3	53	4
Illinoian	W. Illinois	M	21	13	4	4	20	13	1			1	55	2

Transparent minerals in all analyses recalculated to 100 percent.

A – Andrews (1958), average 4 analyses.
B – Andrews (1958), average 6 analyses.
C – Andrews (1958), average 2 analyses.
D – Swineford and Williams (1945), average 51 analyses.
E – Andrews (1958), average 3 analyses.
F – This report, average 10 analyses (Samples 53, 54, 82, 1684–C, 1689, 1700, 1709, 1723, 1726, 1750.
G – This report, average 5 analyses (Samples 41, 43, 45, 748, 1694).
H – This report, average 3 analyses (Samples 71, 73, 75).
I – Pryor (1960), average 37 analyses.
J – Pinsak (1956), average 10 analyses.
K – Andresen (1961), average 3 analyses.
L – This report, average 6 analyses (Samples 61, 1201, 1203, 1207, 1708, 1746).
M – This report, average 5 analyses (Samples 1225, 1712, 1713, 1714, 1731).

The heavy mineral suite in the gravel called "Lafayette" at Hamilton, about 8 miles north of the area mapped in this study, is similar in general to the Baylis Formation, but one sample (1677) contained an unusually high percentage of epidote.

Two samples (55, 56), called Baylis (?) and collected from exposures near the bottom of a ravine a mile south of Baylis, differ from the typical Baylis in containing 4 to 6 percent hornblende and 4 to 5 percent epidote and therefore may represent mixing of Baylis material with Pleistocene deposits.

At Wedron in north central Illinois, a deposit assigned to the Tertiary (Willman and Payne, 1942) may be a Cretaceous outlier. It yielded a tourmaline-zircon-garnet suite (samples 1669 and 1670).

Light Minerals

Counts of the light mineral fraction were made on only two samples from the Baylis Formation. They showed 11 to 14 percent total feldspars, 8 to 12 percent potash feldspars and 2 to 3 percent soda-lime feldspars. These contrast with the glacial deposits of the region which generally contain about 20 percent feldspar, nearly half of which is soda-lime feldspar.

Clay Minerals

Clay mineral analyses were made of 55 samples of Baylis Formation and 10 samples of Dakota Formation from Guthrie County, Iowa. Analyses of McNairy Formation from the upper part of the Mississippi Embayment (Pryor and Glass, 1961), from the Cretaceous deposits of Kansas (Merriam and others, 1959; Plummer and others, 1954), and from the Atlantic Coastal Plain (Groot and Glass, 1960) were used for comparison.

Montmorillonite, as used here, includes all clay material that, when treated with ethylene glycol, yields a well defined diffraction peak at about 17Å (5.1°, 2θ). Chlorite is used here to include all 14Å material that does not expand with ethylene glycol. Illite and kaolinite are used as generally accepted. The values for kaolinite and chlorite are combined in tables 3 and 5; the values for montmorillonite and illite are given for each.

A clay material of particular importance in the Baylis Formation, as well as in the B-zones of the buried weathering profiles developed in Pleistocene deposits, does not fit properly any of the discretely defined clay minerals. On X-ray diffraction traces, this material, when treated with ethylene glycol, appears as a broad diffuse diffraction maximum ranging across the 17Å position. All gradations have been observed, as illustrated in figure 2, from the sharply defined peak that characterizes montmorillonite (samples 1802, 1772) to a very broad and almost indistinguishable maximum that spreads across the range of the montmorillonite peak (sample 1766). The sharply defined diffraction peak of montmorillonite indicates homogeneous swelling material, whereas the broad, highly diffuse maximum indicates heterogeneous-swelling mixed-lattice material. Intermediate diffraction traces may represent mixtures of these two materials but probably show various stages of partial alteration of clay minerals. The observed characteristics may be due, at least in part, to extremely finely divided clay particles. This heterogeneous swelling material was informally called expandable vermiculite (Frye, Willman, and Glass, 1960) because it was thought to be an alteration product of vermiculite derived from illite and chlorite. We no longer use the term because it does not

seem desirable to include this material in vermiculite. Because of the general widespread occurrence of this material in the B-zones of in-situ buried soil profiles, particularly in the Pleistocene sequence in Illinois, we here use the informal designation B-clay. The term B-clay applies to heterogeneous swelling material derived from the weathering of illite and chlorite and possibly montmorillonite. As the X-ray diffraction traces of glycolated samples (fig. 2) display progressively more diffuse maxima, quantitative calculations of clay minerals become impractical or impossible, and the use of the term montmorillonite becomes inapplicable. Quantitative calculations for only those samples that show a well defined montmorillonite peak are given in table 3. Where found in the Baylis Formation, B-clay is unrelated to weathering profiles indicating that this material is capable of being eroded, transported, and deposited without losing its identity.

The clay minerals present in the Baylis Formation represent the minerals, or the alteration products of these minerals, in the source areas to the north and northeast. Illite occurs abundantly in the Paleozoic rocks of the region. Kaolinite occurs in the Paleozoic rocks, but it may be derived from the weathering of Paleozoic and older rocks of the source region. Some of the kaolinite may have been derived from alteration of volcanic ash falls (Waage, 1961), and it may have come in part from the alteration of montmorillonite (Altschuler, Dwornik, and Kramer, 1963) or of B-clay. The occurrence of abundant kaolinite above this major unconformity is consistent with its concentration above other major unconformities in the Midwest. Montmorillonite is rare in the pre-Cretaceous rocks of the Midwest (Grim, 1953), and its abundance in the Baylis Formation cannot be accounted for as a detrital mineral from pre-Cretaceous rocks. Although montmorillonite generally occurs throughout the Baylis Formation, it is particularly abundant in certain beds, and presumably it was formed either by the alteration of volcanic ash blown into the region from the west (Grim, 1953), or by alteration of pre-existing clay minerals. B-clay is universally present in the well developed buried in-situ weathering profiles of Illinois, but it has not been recognized in the Paleozoic rocks of the Midwest. In the Baylis Formation, however, it is a common constituent unrelated to weathering profiles and therefore is judged to have been derived as detrital material from the weathering profiles that had developed in the source region. The absence of chlorite may also suggest derivation from a deeply weathered source region.

The clay minerals of the Baylis Formation (figs. 2, 3, and 4) distinguish the unit from the Pennsylvanian and Mississippian shales below it, which are characterized by abundant illite with minor amounts of kaolinite, chlorite, and mixed-layer material. Although yielding a consistent and highly distinctive heavy mineral suite, the clay mineral composition of the Baylis ranges widely. Some individual samples contain large amounts of montmorillonite similar to the Kansan till of the area (figs. 2, 5). However, such zones are interbedded with others that are readily distinguishable from Pleistocene deposits by their high kaolinite (fig. 4) or their high kaolinite-illite assemblages (fig. 3). Another clay assemblage in the Baylis (fig. 2, sample 1766; fig. 5, sample 1684-C), composed essentially of kaolinite and B-clay, resembles that in a weathering profile on Kansan till, but it is not the result of in-situ weathering.

The clay mineral assemblages in the Dakota Formation of Guthrie County, Iowa, are like those of the Baylis Formation in containing abundant kaolinite or montmorillonite. Figure 3 shows the similarity of the kaolinite-illite clay compositions of the Dakota Formation in Iowa to the Baylis Formation in Illinois.

The high montmorillonite clays from the two areas are shown in figure 2 (samples 1802 and 1772). In Iowa, as in Illinois, the high montmorillonite clays are interzoned with high kaolinite-illite clays. Still farther west similar compositions have been reported from the Dakota Formation in Kansas. A kaolinite–B-clay assemblage from Ellsworth County, Kansas (Plummer and others, 1954, fig. 6) resembles those from the Baylis (fig. 2, sample 1766; fig. 5, sample 1684-C), and kaolinite-illite assemblages from Kansas (Plummer and others, 1954, figs. 5 and 7; Merriam and others, 1959) resemble this type in the Baylis and in the Dakota Formation in Iowa (fig. 3).

The clay minerals in the Cretaceous McNairy Formation of extreme southern Illinois (fig. 4) are essentially all kaolinite (Pryor and Glass, 1961). Such a composition has been observed in one sample from the Baylis (fig. 4, sample 1711). Clay mineral compositions similar to those in the Midwest have been reported also from the Cretaceous of the northern Atlantic Coastal Plain (Groot and Glass, 1960).

In view of the high kaolinite content of some of these Cretaceous deposits the possibility of a Cretaceous age should be entertained for some of the local high kaolinite deposits on the bedrock at various places in Illinois, for example, at Wedron (fig. 4).

PLEISTOCENE SERIES

The presence of glacial deposits of both Kansan and Illinoian ages in this region was described by Leverett in 1899, and a generalized boundary between the two was drawn. Since that time, several different interpretations, shown on figure 7, have been presented for the limit of Illinoian glaciation (Cox, 1929; Weller and others, 1945; Ekblaw, G. E., in Flint and others, 1959; Leighton and Brophy, 1961). The position of this boundary has been reexamined using recently developed mineralogical criteria (Willman, Glass, and Frye, 1963). No Illinoian till was found in a considerable area west of the Mendon Moraine where it had been mapped. Thus it was necessary to reevaluate the Pleistocene stratigraphy of the region. Mendon Moraine is used for the morphostratigraphic unit that includes the end moraine, ground moraine, and associated deposits.

Nebraskan Stage

No till of undoubted Nebraskan age has been recognized in the region, but outwash deposits of Nebraskan age are described in the Zion Church geologic section. At that locality, calcareous pro-Kansan silt and Kansan till overlie Afton Soil developed in gravel that contains igneous and metamorphic rock types.

There is an area beyond the Illinoian glacial limit, along the Baylis-Beverly ridge and southward, where thin and discontinuous deposits of lag gravel containing some igneous rocks occur on the eroded surface of Paleozoic and Cretaceous rocks and are overlain by loess. In part of this area from southeast of Baylis to the vicinity of Beverly, glacial materials are so rare that it may not have been glaciated. Elsewhere, this area presents a strong contrast with the well preserved drift of Kansan age to the northwest and may have been covered only by Nebraskan glaciers. Within the area characterized by till of recognized Kansan age, leached waterlaid deposits between this till and the bedrock (for example, Horberg, 1956, geologic section 13) may be of Nebraskan or Aftonian age.

The heavy mineral suite from one Nebraskan sample (1743) from the Zion Church geologic section is similar to the suites from the overlying till (Kansan) and reflects a northwestern source.

Kansan Stage

In the region between the Mendon Moraine and Mississippi Valley (fig. 7), the surface till previously has been called Illinoian. We now assign this till to a Kansan age on the basis of the following: (1) stratigraphic sequence, (2) topographic expression, (3) heavy mineral suites, (4) carbonate minerals, and (5) clay minerals.

Within the area previously mapped as Illinoian we were unable to find any sections where two tills are separated by an interglacial soil, or even by a leached zone. At no place was the Yarmouth Soil overlain by a younger till. However, at a few places the Yarmouth Soil developed in till of Kansan age is overlain by Loveland Silt or Illinoian outwash that have a Sangamon Soil in the top (for example, in the Zion Church geologic section; in NE$\frac{1}{4}$ SW$\frac{1}{4}$ SE$\frac{1}{4}$ sec. 15, T. 1 S., R. 6 W.; and along Mill Creek, NW$\frac{1}{4}$ SE$\frac{1}{4}$ sec. 9, T. 2 S., R. 8 W.). At many places, it appears that the Yarmouth Soil was eroded from this region during the period of dissection of the Kansan till plain. The previously described examples of Yarmouth Soil within this area (Horberg, 1956) that have been reexamined are calcareous and are judged to be intra-Kansan deposits rather than soil profiles. At many localities, the dissected surface of the Kansan till is marked by a superficial zone of lag gravels through which the Sangamon Soil has been developed into the till below. This relation, which also exists on the surface of the tills of Kansan age in southern Iowa and northeastern Kansas (Frye and Leonard, 1952, p. 105), is particularly common in the part of the region that displays a maturely dissected topography. Sangamon Soil developed on till of known Illinoian age rarely has a zone of lag gravels in its upper part. Because of extensive erosion of the Kansan drift during pre-Sangamonian time, the Sangamon Soil is developed generally on deposits of Kansan age in the area west of the Mendon Moraine. The occurrence of Sangamon Soil on Kansan deposits in western Illinois was noted by Horberg (1956).

In the area beyond the Mendon end moraine, the Kansan till plain is as maturely dissected as it is in northern Missouri, southern Iowa, and northeastern Kansas. It is in strong contrast to the flat and relatively undissected uplands characteristic of the Illinoian till plain inside the Mendon end moraine.

In the Mississippi Valley, Loveland Silt (sample 1732) with a Sangamon Soil is characteristic of the region beyond Illinoian glaciation, and its presence at a few places just outside the Mendon end moraine suggests that Illinoian glaciers did not extend beyond the moraine. Also, the widespread presence along McGee Creek, outside the Mendon end moraine, of Illinoian lake deposits (samples 1754, 1756) suggests that the moraine marks the limit of Illinoian glaciers. This relationship is particularly well shown by exposures in roadcuts (samples 1837-1839) where laminated silts and very fine sands (deposited in a pro-Illinoian lake) overlain by coarse Illinoian outwash containing a Sangamon Soil occur about 2 miles in front of the Mendon Moraine. The high illite content of these deposits clearly shows that they were derived from the advancing Illinoian glacier. Till deposited by the Kansan glacier from the northwest (Willman, Glass, and Frye, 1963) is characterized by about twice as much epidote as garnet (table 4), and till deposited by the Illinoian glaciers from the northeast by more garnet than epidote. Outside the Mendon Moraine all till samples examined, including many from till previously

called Illinoian, have the heavy mineral assemblage characteristic of the Kansan from the northwest.

In western Illinois, the ratio of calcite to dolomite has proven consistently to be a valid means of separating tills of Kansan and Illinoian age (Willman, Glass, and Frye, 1963). X-ray analyses show that in Kansan till in the area of this study calcite only is present or calcite exceeds dolomite, whereas in the Illinoian till dolomite exceeds calcite (table 5). None of the till samples collected in the area west of the Mendon Moraine were high in dolomite.

Likewise, clay mineral compositions differentiate the Kansan till (northwestern source) from the Illinoian till (northeastern) and from the Cretaceous Baylis Formation (fig. 5). Montmorillonite is generally higher in Kansan till (72% average) than in Illinoian till (61% average), but the range in the two tills may overlap. However, illite is always higher in the Illinoian (20% average) than in the Kansan till (10% average). The highest illite observed in Kansan till was 14 percent and the lowest observed in Illinoian till was 15 percent (table 5). Chlorite is generally present in Illinoian till and lacking in Kansan till.

The differences in mineral composition of the tills are also reflected in the associated silts and sands (fig. 5). The sequence of analyses from the Pryor School geologic section (fig. 6 and table 3) shows the striking change in composition upward. It will be noted that the basal part of the Petersburg Silt (sample 1789) has a composition similar to the Kansan till below (sample 1788). This material presumably was derived from erosion of the till. Higher in the Petersburg (samples 1790, 1816), the strong sorting influence of water transport from the advancing Illinoian glacier is shown by the greater abundance of illite than in the Illinoian till. At the top of the Petersburg (sample 1791), the composition of the silt is indistinguishable from the Illinoian till (sample 1792) that rests on it.

Illinoian Stage

Till forming the surface drift of the Mendon Moraine displays (tables 4 and and 5) the characteristics that have been described for Illinoian till (Willman, Glass, and Frye, 1963). As elsewhere in this part of Illinois, it is characterized by higher garnet, higher dolomite, and higher illite and chlorite relative to the Kansan. Its stratigraphic relation to the Kansan is well displayed in the Pryor School geologic section and in subsurface sample sets (10,693 and 30,000).

Previously, a principal line of evidence for extending the Illinoian farther west was the assumption that the Beverly-Baylis ridge was a glacial moraine (Leverett, 1899, p. 60; Leighton and Brophy, 1961, p. 6). As this ridge is composed of Baylis Formation with little glacial material on it, the topographic evidence is no longer valid. Likewise, at Payson, where Illinoian till was formerly thought to be present, several exposures near the town show only thin lag gravel overlain by loess and resting on bedrock. Also, the topography appears to be bedrock controlled and not morainic.

Because Illinoian drift appears not to have been deposited in the Payson area, it is here proposed that the name Payson Substage, introduced by Leighton and Willman (1950, p. 602) and later modified (Willman, Glass, and Frye, 1963) to include Petersburg Silt, be abandoned and the name Liman Substage adopted. The name Liman comes from the Pryor School geologic section, described in this report, in Lima Township, Adams County, Illinois. The Liman Substage is defined as encompassing the time span represented by Petersburg Silt, Mendon till, and other Illinoian deposits stratigraphically below the deposits of the Jacksonville Moraine.

SUMMARY AND CONCLUSIONS

Cretaceous

The Baylis Formation is recognized as a new stratigraphic entity in Adams and Pike Counties, Illinois. This formation is assigned a Cretaceous age because of its stratigraphic relations, topographic position, and general lithology and because of the composition of its gravels, heavy and light mineral suites in the sand fraction, and clay mineral assemblages.

The similarities of heavy and light mineral suites, clay mineral assemblages, lithology, and even color and appearance in outcrops to beds of known Cretaceous age in central Iowa and central Kansas, coupled with the dissimilarity in each of these characteristics with any other known stratigraphic unit in the Midwest, lead us to conclude that the Baylis Formation is Cretaceous in age, even though we have found no fossils in the formation.

A Cretaceous age is consistent with the stratigraphic relations of the Baylis Formation. It occurs above an unconformity that truncates Hannibal, Burlington, Keokuk, Warsaw, and Salem Formations of Mississippian age and Abbott and Carbondale Formations of Pennsylvanian age. At most places where the Baylis has been observed above Mississippian and Pennsylvanian shales, the underlying deposits are distinctly weathered. This relationship suggests that the pre-Cretaceous erosion surface in western Illinois is relatively close to the present bedrock surface, which has been called the Calhoun Peneplain of Tertiary age (Horberg, 1950; Rubey, 1952).

From its stratigraphic relations, the Baylis Formation could be Tertiary in age. The physical and mineralogical similarity to known Cretaceous deposits in western Iowa is perhaps the strongest reason for concluding that the Baylis Formation is Cretaceous rather than Tertiary. The lack of evidence of Tertiary deposits, other than the scattered thin deposits of chert gravel, throughout the entire region northward from the Mississippi Embayment and eastward from central Kansas and Nebraska, makes it difficult to accept the presence of as much as 100 feet of Tertiary sediments in this locality.

Chert-quartz-quartzite gravels on the pre-Cretaceous surface long have been recognized as the Windrow Gravel in Wisconsin, Minnesota, and Iowa (Thwaites and Twenhofel, 1921; Andrews, 1958); the Ostrander Member of the Dakota Formation in Minnesota (Stauffer and Thiel, 1941); in the base of the Cheyenne, Kiowa, and Dakota Formations across central Kansas (Frye, 1955); and as the Tuscaloosa Formation (Pryor, 1960) in the northern part of the Mississippi Embayment. The Hadley Gravel Member of the Baylis Formation is a similar gravel, and, like the Windrow and Tuscaloosa Gravels, it commonly has an iron-cemented zone at the base. Other isolated deposits of high level gravels in Illinois, such as that described at Wedron and generally assigned to the Tertiary, may also be of Cretaceous age. The gravels represent initial Cretaceous sedimentation on the unconformable surface but probably are time-transgressive.

Several lines of evidence suggest that the Baylis Formation is lowermost Gulfian because of its close similarities to the Dakota Formation to the west and northwest.

The major source areas of Cretaceous sediments in the Midwest were described by Potter and Pryor (1961, fig. 14). They recognized three source areas: (1) the metamorphics of the Piedmont Plateau, which contributed to the Cretaceous and Tertiary of the embayment; (2) the lower Paleozoic and crystalline rocks of the

northern Appalachians, which contributed to the Mississippian and Pennsylvanian sediments; and (3) the Precambrian rocks to the north, which contributed to the lower Paleozoic sediments and to the Pleistocene deposits.

The McNairy sediments of extreme southern Illinois clearly were derived from the metamorphic rocks of the Piedmont Plateau, but the sediments of the Baylis Formation and of the Dakota Formation to the northwest and west of Illinois came from the Precambrian rocks to the north.

The heavy minerals in the Baylis Formation reflect the composition of the northern source, in contrast to those of the "Lafayette" at the head of the embayment, which indicate a southeastern source. An intermediate province with higher garnet in eastern Ontario (Dreimains and others, 1957) may have been the source of the high garnet sediments at Wedron. If the Ohio River Formation is Cretaceous, it probably was derived from a more easterly source.

The heavy mineral suites from midwestern Cretaceous deposits are composed of moderately to highly resistant minerals derived largely from deeply weathered surfaces. The heavy minerals are not as restricted to resistant types as are those in the underlying Paleozoic rocks, but they contain few of the relatively nonresistant minerals so prevalent in the glacial deposits.

In this area, it appears that the pre-Cretaceous surface was relatively flat and featureless and that the Baylis sediments were laid down as sheet-like deposits. Although the absence of marine fossils might indicate a nonmarine origin, other characteristics suggest deposition in a littoral zone of a shore line with exceptionally gentle gradients. Factors indicating this environment are the general presence of some gravel at the base, the alternation of clean white sand with very clayey sands, and the alternation of beds characterized by high kaolinite with beds characterized by high montmorillonite. Previous studies of Cretaceous deposits suggested that high kaolinite clays occur in a nonmarine environment and high montmorillonite clays occur in a marine environment (Groot and Glass, 1960; Pryor and Glass, 1961; Waage, 1961).

Within this general region, some gravel deposits occur at an elevation slightly below the projected base of the Baylis Formation (for example, near Richfield, Adams County). Although they resemble the Hadley Gravel Member in general appearance, they contain a higher percentage of brown chert, and they may have been reworked and deposited in Tertiary time. South of this region, the Grover gravels display similarities to the Hadley Gravel Member and may be derived largely from the reworking of the Hadley Gravel.

Some deposits that have been called Grover (for example, near Golden Eagle, Calhoun County) contain boulders of quartzite more than two feet in diameter, and the fine matrix in which the boulders occur has an exceptionally high feldspar content (samples 43 and 748). They may have been deposited by the Nebraskan glacier.

Pleistocene

An extensive area on the crest and flanks of the Baylis-Beverly ridge may not have been glaciated. Along the crest of the ridge northwestward from about half way between Pittsfield and Baylis, the only evidence observed that glaciers were present is a few boulders at Kingston.

Till of Nebraskan age, although nowhere identified with certainty in this area (fig. 1) is presumed from its regional relations to have covered at least part of the area (Flint and others, 1959). In fact, at the Independence geologic section, the incorporation of lag gravels in the upper part of the Yarmouth Soil on till and below Loveland Silt leads to speculation that this till may be Nebraskan rather

than Kansan. In addition, the large boulders in the deposit near Golden Eagle in Calhoun County strengthen the possibility of a southward extension of Nebraskan glaciers (Willman and Frye, 1958) much beyond where it has been mapped (Flint and others, 1959). Furthermore, in much of western Pike County and extreme southern Adams County, the only evidence of glaciation consists of thin lag gravel on the bedrock. These gravels contain some igneous and metamorphic rocks and may be remnants of Nebraskan deposits. The fact that Nebraskan outwash entered the region is shown clearly by the Zion Church geologic section.

Till of Kansan age is widely exposed in Adams County west of the Illinoian glacial boundary, except along the Baylis-Beverly ridge. This till occurs below Illinoian till in eastern Adams County and farther east in Brown County. Its absence from the ridge suggests that the Kansan glacier, advancing from the northwest, encountered the ridge near the limit of glacial advance and was diverted into lobes on both sides of the ridge.

The data presented here confirm our previous conclusions (Willman, Glass, and Frye, 1963) that Kansan and Illinoian tills can be differentiated on the basis of their mineral compositions. No evidence was found that Illinoian glaciers covered the area west of the Mendon Moraine, and all of the samples of till examined from that area are from a northwestern source. It is possible, of course, that thin local deposits of Illinoian till may be undiscovered beyond the Mendon Moraine because of the large areas that are lacking in exposures. The name Mendon end moraine is used here not only for the well defined morainic ridge north and south from Mendon but also for the discontinuous and locally indistinct morainic ridge that marks the limit of Illinoian glaciation southward to its crossing of Illinois River at Pearl, in southeastern Pike County.

Because the town of Payson is more than 15 miles beyond the limit of Illinoian glaciation, it is no longer an appropriate type locality for an Illinoian substage. The name Liman is proposed for the earliest Illinoian substage encompassing the time of deposition of Petersburg Silt, Mendon till, and other Illinoian deposits stratigraphically below Jacksonville till.

REFERENCES

Altschuler, Z. S., Dwornik, E. J., and Kramer, Henry, 1963, Transformation of montmorillonite to kaolinite during weathering: Science, v. 141, p. 148-152.

Andresen, M. J., 1961, Geology and petrology of the Trivoli Sandstone in the Illinois Basin: Illinois Geol. Survey Circ. 316, 31 p.

Andrews, G. W., 1958, Windrow Formation of Upper Mississippi Valley region — A sedimentary and stratigraphic study: Jour. Geology, v. 66, no. 6, p. 597-624.

Cox, B. B., 1929, Geology and mineral resources of the Quincy and Liberty Quadrangles: Illinois Geol. Survey open-file ms., 114 p.

Dreimanis, A., Reavely, G. H., Cook, R. J. B., Knox, K. S., and Moretti, F. J., 1957, Heavy mineral studies in tills of Ontario and adjacent areas: Jour. Sed. Petrology, v. 27, p. 148-161.

Flint, R. F., and others, 1959, Glacial map of the United States east of the Rocky Mountains: New York, Geol. Soc. America.

Frye, J. C., 1955, The erosional history of the Flint Hills: Kansas Acad. Sci. Trans., v. 58, p. 79-86.

Frye, J. C., 1963, Problems of interpreting the bedrock surface of Illinois: Illinois Acad. Sci. Trans., v. 56, no. 1, p. 3-11.

Frye, J. C., Glass, H. D., and Willman, H. B., 1962, Stratigraphy and mineralogy of the Wisconsinan loesses of Illinois: Illinois Geol. Survey Circ. 334, 55 p.

Frye, J. C., and Leonard, A. B., 1952, Pleistocene geology of Kansas: Kansas Geol. Survey Bull. 99, 230 p.

Frye, J. C., Willman, H. B., and Glass, H. D., 1960, Gumbotil, accretion-gley, and the weathering profile: Illinois Geol. Survey Circ. 295, 39 p.

Grim, R. E., 1953, Clay mineralogy: New York, McGraw-Hill Book Co. Inc., 384 p.
Groot, J. J., and Glass, H. D., 1960, Some aspects of the mineralogy of the northern Atlantic Coastal Plain: 7th Natl. Conf. on Clays and Clay Minerals, Washington, D. C., p. 271-284.
Horberg, Leland, 1950, Bedrock topography of Illinois: Illinois Geol. Survey Bull. 73, 111 p.
Horberg, Leland, 1956, Pleistocene deposits along the Mississippi Valley in central-western Illinois: Illinois Geol. Survey Rept. Inv. 192, 39 p.
Leighton, M. M., and Brophy, J. A., 1961, Illinoian glaciation in Illinois: Jour. Geology, v. 69, p. 1-31.
Leighton, M. M., and Willman, H. B., 1950, Loess formations of the Mississippi Valley: Jour. Geology, v. 58, p. 599-623.
Leverett, Frank, 1899, The Illinois glacial lobe: U. S. Geol. Survey Mon. 38, 817 p.
Merriam, D. F., Atkinson, W. R., Franks, P. C., Plummer, Norman, and Preston, F. W., 1959, Description of a Dakota (Cretaceous) core from Cheyenne County, Kansas: Kansas Geol. Survey Bull. 134, pt. 1, p. 1-104.
Pierce, R. L., 1961, Lower Upper Cretaceous plant microfossils from Minnesota: Minnesota Geol. Survey Bull. 42, 86 p.
Pinsak, A. P., 1956, High-silica sand potentialities of the Ohio River Formation: Indiana Geol. Survey Bull. 9, 54 p.
Plummer, Norman, Swineford, Ada, Runnels, R. T., and Schleiche, J. A., 1954, Chemical, petrographic, and ceramic properties of four clays from the Dakota Formation in Kansas: Kansas Geol. Survey Bull. 109, pt. 10, p. 153-216.
Potter, P. E., 1955, The petrology and origin of the "Lafayette" gravels: Jour. Geology, v. 63, p. 1-38, 115-132.
Potter, P. E., and Pryor, W. A., 1961, Dispersal centers of Paleozoic and late clastics in the Upper Mississippi Valley and adjacent areas: Geol. Soc. America Bull. v. 72, p. 1195-1250.
Pryor, W. A., 1960, Cretaceous sedimentation in Upper Mississippi Embayment: Am. Assoc. Petroleum Geologists Bull. v. 44, p. 1473-1504.
Pryor, W. A., and Glass, H. D., 1961, Cretaceous-Tertiary clay mineralogy of the Upper Mississippi Embayment: Jour. Sed. Petrology, v. 31, p. 38-51.
Pryor, W. A., and Ross, C. A., 1962, Geology of the Illinois part of the Cairo, LaCenter, and Thebes Quadrangles: Illinois Geol. Survey Circ. 332, 39 p.
Ross, C. A., 1963, Structural framework of southernmost Illinois: Illinois Geol. Survey Circ. 351, 27 p.
Rubey, W. W., 1952, Geology and mineral resources of the Hardin and Brussels Quadrangles (in Illinois): U. S. Geol. Survey Prof. Paper 218, 179 p.
St. John, O. H., 1870, Geology of the middle region of western Iowa and other counties: Gutherie County, in White, C. A., Report on the Geological Survey of the State of Iowa: v. II, 443 p.
Salisbury, R. D., 1892, On the northward and eastward extension of the pre-Pleistocene gravels of the Mississippi Basin: Geol. Soc. America Bull., v. 3, p. 183-186.
Stauffer, C. R., and Theil, G. A., 1941, The Paleozoic and related rocks of southeastern Minnesota: Minnesota Geol. Survey Bull. 29, 261 p.
Swineford, Ada, and Williams, H. L., 1945, The Cheyenne Sandstone and adjacent formations of a part of Russell County, Kansas: Kansas Geol. Survey Bull. 60, pt. 4, p. 101-168.
Tester, A. C., 1931, The Dakota Stage of the type locality: Iowa Geol. Survey, v. 35, p. 199-332.
Thwaites, F. T., and Twenhofel, W. H., 1921, Windrow Formation; an upland gravel formation of the dirftless and adjacent areas of the Upper Mississippi Valley: Geol. Soc. America Bull., v. 32, p. 293-314.
Waage, K. M., 1961, Stratigraphy and refractory clayrocks of the Dakota Group along the northern front range, Colorado: U. S. Geol. Survey Bull. 1102, 154 p.
Wayne, W. J., 1960, Stratigraphy of the Ohio River Formation: Indiana Geol. Survey Bull. 21, 44 p.
Weller, J. M., and others, 1945, Geologic map of Illinois: Illinois Geol. Survey.
Willman, H. B., and Frye, J. C., 1958, Problems of Pleistocene geology in the greater St. Louis area: Geol. Soc. America Field Trip Guidebook, St. Louis, p. 9-19.
Willman, H. B., Glass, H. D., and Frye, J. C., 1963, Mineralogy of glacial tills and their weathering profiles in Illinois. Part 1. Glacial Tills: Illinois Geol. Survey Circ. 347, 55 p.
Willman, H. B., and Payne, J. N., 1942, Geology and mineral resources of the Marseilles, Ottawa, and Streator Quadrangles: Illinois Geol. Survey Bull. 66, 388 p.

TABLE 1 – DESCRIPTION OF SAMPLES

Sample Number[1]	Location ¼ Sec., T.–R., County	Stratigraphic Unit (feet below top)	Analyses Table No.	Analyses Fig. No.
41	SE NW SW 3, 44N–3E, St. Louis Co., Mo.	Grover gravel	2	
43	NE NE SE 36, 13S–2W, Calhoun	Grover gravel	2	
45	SE NW SW 3, 44N–3E, St. Louis Co., Mo.	Grover gravel (5)	2, 3	
47	SE SE SW 6, 4N–8W, Hancock	Baylis Fm. (10)	2	
53	SW NW SW 7, 3S–6W, Adams	Baylis Fm. (5)	2	
54	do.	Baylis Fm. (12)	2	
55	NW NW NW 19, 4S–4W, Pike	Baylis Fm. (?)	2	
56	do.	Baylis Fm. (?)	2	
57	SW SE SW 13, 4S–4W, Pike	Kans. till (5)	2	
59	SE SW SE 9, 4S–4W, Pike	glacial lag gravel	2	
60	do.	Nebr. or Kans. till	2, 3, 5	
61	SE SW 13, 4S–5W, Pike	Kans. till (8)	2, 3, 5	
62	SE SE NW 10, 6S–4W, Pike	Nebr. gravel	2	
68	SE NW SW 3, 44N–3E, St. Louis Co., Mo.	Grover gravel (15)	3	
71	NE NE 1, 27N–10E, Stoddard Co., Mo.	"Lafayette" gravel	2	
73	SE NW NE 26, 29N–14E, Scott Co., Mo.	"Lafayette" gravel (10)	2	
75	SW SW SW 7, 16S–1W, Pulaski	"Lafayette" gravel (5)	2	
82	NE cor. NW 17, 3S–6W, Adams	Baylis Fm.	2	
265	NE NW SE 16, 7S–2W, Pike	Ill. outwash (20)	2	
437	SW SW SW 3, 15N–4E, Henry	Nebr. – Ill. gravel	2	
748	NE NE SE 36, 13S–2W, Calhoun	Grover gravel	2, 3	
954	SE SE SE 31, 3N–8W, Hancock	Ill. till (10)	2, 3, 5	
1201	NW NW SW 22, 2S–8W, Adams	Kans. till (6)	2, 3, 5	
1203	NW NE SW 35, 1S–8W, Adams	Kans. till (39)	2, 3, 5	
1207	do.	Kans. till (9)	2, 3, 5	
1225	SE cor. 26, 2N–9W, Adams	Ill. outwash (6)	2	
1669	NE SE SE 9, 34N–4E, LaSalle	Cretaceous (?) gr. (6)	2	
1670	do.	Cretaceous (?) gr. (2)	2	
1673	do.	Cretaceous (?) clay (7)	3	4
1677	SW cor. SE 6, 4N–8W, Hancock	Baylis Fm. (7)	2, 3	
1679	SE SW SE 12, 3S–7W, Adams	Baylis Fm. (5)	3	
1682	NW SW SW 7, 3S–6W, Adams	Baylis Fm. (12)	3	
1683	do.	Baylis Fm. (4)	3	
1684–A	SW NW SW 7, 3S–6W, Adams	Baylis Fm. (35)	3	3
1684–C	do.	Baylis Fm. (10)	2, 3	5
1686	do.	Baylis Fm. (7)	3	
1689	NE cor. SW 5, 3S–6W, Adams	Baylis Fm. (2)	2	
1691	NW NW NE 8, 3S–6W, Adams	Baylis Fm. (3)	3	
1692	NW NW SE 8, 3S–6W, Adams	Baylis Fm. (6)	2	
1694	NE NW SE 2, 8S–3W, Calhoun	Grover gravel (3)	2, 3	
1695	do.	Grover gravel (2)	3	
1700	NW SW SE 31, 4S–4W, Pike	Baylis Fm. (23)	2	
1703	NE NE NW 5, 4S–5W, Pike	glacial lag gravel	2	
1704	SW SW SW 29, 3S–5W, Adams	Nebr. or Kans. silt (3)	3	
1706	NE NW NE 8, 5S–3W, Pike	Ill. till	3, 5	
1708	NE NE SW 14, 4S–4W, Pike	Kans. (?) till (17)	2, 3, 5	
1709	NE SE NW 11, 4S–4W, Pike	Baylis Fm. (10)	2, 3	
1711	do.	Baylis Fm. (6)	3	4
1712	NW NE SW 11, 4S–4W, Pike	Ill. till (10)	2, 3, 5	
1713	NW NE SW 16, 3S–4W, Adams	Ill. till	2, 3, 5	5
1714	NE SW SW 17, 3S–4W, Adams	Ill. till (3)	2, 3, 5	
1715	do.	Ill. silt	3	

TABLE 1 - Continued

Sample Number[1]	Location ¼ Sec., T.-R., County	Stratigraphic Unit (feet below top)	Analyses Table No.	Analyses Fig. No.
1716	NE SE SW 17, 3S-4W, Adams	Ill. silt	3	
1717	do.	Ill. silt	3	
1718	do.	Ill. silt	3	
1720	NW SW NW 19, 4S-4W, Pike	Baylis Fm.	3	2
1722	SW SW SE 24, 4S-5W, Pike	Baylis Fm.	3	
1723	do.	Baylis Fm.	2	
1725	do.	Kans. till	3, 5	
1726	NE cor. SW 36, 3S-5W, Adams	Baylis Fm. (2)	2, 3	
1727	NW cor. SW NE 10, 3S-5W, Adams	Baylis Fm.	3	
1728	SW NE SW 24, 2S-5W, Adams	Ill. till (5)	3, 5	
1729	NW NE NE 24, 2S-5W, Adams	Ill. outwash (32)	3	
1731	do.	Ill. outwash (12)	2	
1732	NW NW NW 14, 2S-5W, Adams	Loveland Silt (10)	3	5
1739	NE NW NW 18, 3S-5W, Adams	Nebr. or Kans. till	3, 5	
1740-X	NE NE NE 11, 3S-6W, Adams	Baylis Fm.	3	
1741-X	do.	Baylis Fm.	3	
1742-X	do.	Baylis Fm.	3	
1743	SE SE SW 9, 3S-8W, Adams	Nebr. gravel (4)	2	
1745	do.	pro-Kans. silt (4)	3	
1746	do.	Kans. till (27)	2, 3, 5	
1748	NW NW SW 3, 2S-8W, Adams	Kans. till	3, 5	
1749	SE NW NE 17, 1S-8W, Adams	Kans. till (14)	3, 5	
1750	SE NE NW 35, 1N-8W, Adams	Baylis Fm.	2	
1752	NW NE NE 1, 1S-6W Adams	Ill. till (10)	3, 5	
1753	SW SE SE 11, 1S-6W, Adams	Kans. silt (3)	3	
1754	do.	Ill. sand (10)	3	
1756	SW SE SE 14, 1S-6W, Adams	Ill. lake deposit (16)	3	
1758	NE SW SE 15, 1S-6W, Adams	pro-Kans. silt (8)	3	5
1759	do.	Kans. till (8)	3, 5	5
1764	SW SW NW 2, 1S-6W, Adams	Kans. clay	3	
1766	SW NW SE 26, 1N-8W, Adams	Baylis Fm. (9)		2
1770	SE SE SE 33, 1N-8W, Adams	Baylis Fm.	3	3
1771	SW SW SE 17, 5S-4W, Pike	Baylis Fm.	3	
1772	do.	Nebr. or Kans. till	3, 5	2
1773	SW NW SW 17, 4S-4W, Pike	Baylis Fm. (6)	3	
1774	do.	Baylis Fm. (4)	3	2
1775	SW SW NE 29, 3S-4W, Pike	Baylis Fm.	3	
1776	NE NW SE 29, 3S-4W, Pike	Baylis Fm. (6)	3	
1777	do.	Baylis Fm. (4)	3	
1778	do.	Baylis Fm. (2)	3	
1779	do.	Baylis Fm. (1)	3	
1780	NE NE NW 16, 1S-7W, Adams	Kans. till	3, 5	
1781	SE NE NE 4, 1S-8W, Adams	pro-Kans. silt	3	
1785	SE SW SE 21, 1N-8W, Adams	Baylis Fm.	3	2
1786	NE NE NW 23, 1N-8W, Adams	Baylis Fm.	3	2
1787	NE NW SW 7, 1N-7W, Adams	Ill. till	3, 5	
1788	NE NE SE 11, 2N-8W, Adams	Kans. till (3)	3, 5	6
1789	do.	Petersburg Silt (10)	3	6
1790	do.	Petersburg Silt (6)	3	6
1791	do.	Petersburg Silt (3)	3	6
1792	do.	Ill. till (9)	3, 5	6
1793	SE SW SW 8, 2N-8W, Adams	Kans. till (6)	3, 5	
1794	SE SW NE 5, 2N-8W, Adams	Ill. till	3, 5	

TABLE 1 – Continued

Sample Number[1]	Location ¼ Sec., T.-R., County	Stratigraphic Unit (feet below top)	Analyses Table No.	Analyses Fig. No.
1795	NW NE SW 19, 3N-8W, Hancock	Kans. till	3, 5	
1797	NE NE NE 16, 78N-31W, Guthrie Co., Iowa	Dakota Fm. (28)	3	
1798	do.	Dakota Fm. (23)	3	3
1799	do.	Dakota Fm. (18)	3	
1800	do.	Dakota Fm. (8)	3	
1801	do.	Dakota Fm. (6)	3	3
1802	do.	Dakota Fm. (4)	3	2
1804	do.	Kans. till (20)	3	
1807	NE NE SE 9, 78N-31W, Guthrie Co., Iowa	Dakota Fm. (3)	3	3
1808	NE SE NW 9, 78N-31W, Guthrie Co., Iowa	Dakota Fm. (6)	3	
1809	SW NW SW 35, 79N-31 W, Guthrie Co., Iowa	Dakota Fm. (15)	3	
1813	NE NE SE 11, 2N-8W, Adams	Kans. till (8)	3, 5	
1814	do.	Petersburg Silt (13)	3	
1815	do.	Petersburg Silt (11)	3	
1816	do.	Petersburg Silt (3)	3	6
1817	NE NE SW 29, 3N-8W, Hancock	Ill. till (3)	3, 5	
1824	SW NW SE 18, 6S-3W, Pike	Kans. till (3)	3, 5	
1828	NE NW SE 26, 1N-8W, Adams	Baylis (?) Fm. (4)	3	
1829	do.	Pleistocene (?) sd. (6)	3	
1830	do.	Pleistocene (?) sd. (3)	3	
1831	do.	Pleistocene sdy. clay (8)	3	
1832	do.	Pleistocene sdy. clay (5)	3	
1837	SW cor. 31, 1S-5W, Adams	Petersburg Silt (17)	3	
1838	do.	Petersburg Silt (7)	3	
1839	do.	Petersburg Silt (5)	3	
SS-10693				
40	SE SE SE 33, 1N-6W Adams	Ill. till (25)	3, 5	
70	do.	Ill. till (55)	3, 5	
105	do.	Kans. till (20)	3, 5	
110	do.	Kans. till (25)	3, 5	
SS-30000				
10	SW SE SW 10, 1S-5W, Adams	Ill. till (10)	3, 5	
20	do.	Ill. till (20)	3, 5	
45	do.	Kans. till (25)	3, 5	
55	do.	Kans. till (35)	3, 5	

[1] All sample numbers are in the Illinois State Geological Survey's P–series unless otherwise noted.

TABLE 2 — HEAVY AND LIGHT MINERAL ANALYSES
(.0625 to .250 mm. fraction. Carbonate-free basis)

Sample No.	Opaque[1]		Transparent Heavy Minerals[2]														Light[3]			
	Black	Others	Tourmaline	Zircon	Garnet	Epidote	Rutile	Kyanite	Staurolite	Andalusite	Sillimanite	Actinolite	Hornblende	Enstatite	Hypersthene	Diop.-Aug.	Others	Quartz	K Feldspar	Na-Ca Feldspar	Others
41	80		16	56	1		3	4	9		2						9	70	17	9	4
43[4]	88		17	63	4	4	4		8									59	34	6	1
45[4]	76		36	33	3	4	4	4	4		6	2	2				2	91	3	5	1
47	36	25	26	47	1	2	2	1	14								7				
53	61		34	44			3	3	12	2			1				1				
54	44	18	37	39			3	1	17								3	85	12	2	1
55	84		43	26	1	4	3	4	12				4				3				
56	78		22	45	1	5	2	1	13				6				5				
57	43		6	6	10	44	2	1				5	19			1	6				
59	52		14	7	5	57	2			1	1	5	7			1		85	8	4	3
60	50		17	12	4	44	1	4				7	4				7	83	8	4	5
61	43		12	18	13	21	1			6		2	18	1			8	76	13	6	5
62	34	28	3	64	12				9				9				3				
71	11	52	13	51	10	1	4	1	14		5						1	87	1	1	1
73[5]	35	26	20	29		6	1	7	30		7										
75	9	50		28			2	40	24		6							89	5	3	3
82	79	10	19	53			5	5	16				2					89	8	3	
265	4	19	2		12	12			2				66	1	1	1	3	79	10	8	3
437	46	17	19	20	15	9	1		6				25		4		1	83	7	8	2
748	75	18	6	68		18	1	1	3	1			1				1	63	28	6	3
954	10	15	3	3	13	13			3				62	1			2				
1201	19	8	2	4	6	21							65	1			1				
1203	7	8		2	11	22			4				57	4							
1207	14	10	1	5	11	14		1	4				63		1						
1225	25	11	1		15	16	2		2				61				3				
1669	3	59	46	27	20		1						6								
1670	0	58	52	25	18		2						3								
1677	33	28	33	30	1	19	2	1	9				1				4				
1684C	35	23	52	34	1		2	2	9												
1689	44	17	39	33		3	2	4	17				1		1						
1692	51	12	8	44	2	18	3	7	11				4				3				
1694	41	18	17	82			1														
1700	57	7	19	48	2	4		4	20				2		1						
1703	49	11	15	52	2	16	2	1	6				5				1				
1708	31	14	4	1	15	24	1		6				48	1							
1709	51	14	31	44	3	1	1	6	13						1						
1712	21	18	6	7	20	15			1				51								
1713	18	10	5	6	19	15		1					52		1	1					
1714	14	16	4	6	17	8	1						63		1						
1723	52	11	21	45			4	6	22		1						1				
1726	50	14	32	49		2	5	1	11												
1731	27	8	3	3	28	9	1	1	4				48			2	1				
1743	26	10	2	8		30	2	1	3				50				4				
1746	25	19	4	3	11	12			4				65				1				
1750	51	10	27	62	1		1		9												

[1] Percent of total heavy minerals.

[2] Percent of transparent heavy minerals.

[3] Percent of entire fraction.

[4] Analysis of sand coarser than .044 mm.

[5] Analysis of sand coarser than .500 mm.

TABLE 3 – CLAY MINERAL AND CARBONATE X-RAY ANALYSES

Sample number	Counts per second bulk sample		Clay minerals in < 2μ fraction			Sample number	Counts per second bulk sample		Clay minerals in < 2μ fraction			Sample number	Counts per second bulk sample		Clay minerals in < 2μ fraction		
	Calcite	Dolomite	Percent montmoril-lonite	Percent illite	Percent kaolinite and chlorite		Calcite	Dolomite	Percent montmoril-lonite	Percent illite	Percent kaolinite and chlorite		Calcite	Dolomite	Percent montmoril-lonite	Percent illite	Percent kaolinite and chlorite
45	–	–	53	8	39	1728	–	–	63	18	19	1792	–	–	62	20	18
60	–	–	69	9	22	1729	–	–	41	36	23	1793	–	–	74	10	16
61	–	–	67	13	20	1732	6	24	56	30	14	1794	–	–	68	15	17
68	–	–	88	7	5	1739	–	–	61	13	26	1795	24	15	77	10	13
748	–	–	35	16	49	1740X	–	–	54	17	29	1797	–	–	41	17	42
954	12	40	60	21	19	1741X	–	–	73	11	16	1798	–	–	15	37	48
1201	7	–	67	12	21	1742X	–	–	74	7	19	1799	–	–	80	11	9
1203	24	17	69	12	19	1745	12	7	79	10	11	1800	–	–	4	58	38
1207	16	14	70	13	17	1746	16	–	69	11	20	1801	–	–	29	22	49
1673	–	–	–	2	98	1748	16	–	77	9	14	1802	–	–	71	19	10
1677	–	–	23	35	42	1749	6	–	79	11	10	1804	–	–	73	14	13
1679	–	–	22	40	38	1752	–	–	63	17	20	1807	–	–	–	52	48
1682	–	–	65	13	22	1753	–	–	84	7	9	1808	–	–	16	20	64
1683	–	–	31	23	46	1754	–	–	41	36	23	1809	–	–	–	52	48
1684A	–	–	37	29	34	1756	–	–	86	5	9	1813	27	25	64	12	24
1684C	–	–	30	26	44	1758	10	36	90	4	6	1814	–	–	79	7	14
1686	–	–	49	22	29	1759	–	–	89	3	8	1815	–	–	70	8	22
1691	–	–	62	13	25	1764	–	–	73	7	20	1816	23	37	27	48	25
1694	–	–	20	29	51	1770	–	–	17	34	49	1817	–	–	62	16	22
1695	–	–	20	27	53	1771	–	–	59	13	28	1824	5	–	59	12	29
1704	–	–	88	5	7	1772	–	–	63	11	26	1828	–	–	22	26	52
1706	–	–	60	17	23	1773	–	–	50	14	36	1830	–	–	16	47	37
1708	–	–	71	14	15	1774	–	–	65	15	20	1831	–	–	80	9	11
1709	–	–	48	22	30	1775	–	–	70	7	23	1832	–	–	74	11	15
1711	–	–	10	16	74	1776	–	–	63	13	24	1837	30	27	19	52	29
1712	–	–	53	29	18	1777	–	–	83	7	10	1838	13	26	45	38	17
1713	7	50	54	24	22	1778	–	–	80	7	13	1839	–	–	27	46	27
1714	12	42	59	22	19	1779	–	–	79	8	13	SS–					
1715	10	50	41	40	19	1780	–	–	79	8	13	10693–40	14	42	58	20	22
1716	–	10	27	50	23	1781	–	–	67	12	21	10693–70	12	50	54	22	24
1717	6	20	57	28	15	1785	–	–	50	15	35	10693-105	–	–	76	10	14
1718	35	38	34	48	18	1786	–	–	55	13	32	10693-110	–	–	80	6	14
1720	–	–	51	16	33	1787	–	10	62	16	22	SS–					
1722	–	–	79	13	8	1788	–	–	84	5	11	30000–10	–	–	65	23	12
1725	–	–	68	11	21	1789	–	–	79	6	15	30000–20	–	–	61	25	14
1726	–	–	64	14	22	1790	6	18	29	50	21	30000–45	–	–	77	7	16
1727	–	–	74	9	17	1791	–	–	57	25	18	30000–55	–	–	76	6	18

TABLE 5 – CARBONATE AND CLAY MINERAL ANALYSES OF KANSAN AND ILLINOIAN TILLS

Sample Number	Counts per second, bulk sample		Clay minerals in $<2\mu$ fraction				
	Calcite	Dolomite	Percent montmorillonite	Percent illite	Percent kaolinite and chlorite	Chlorite	Kaolinite
Kansan							
60	–	–	69	9	22	–	+
61	–	–	67	13	20	–	+
1201	7	–	67	12	21	–	+
1203	24	17	69	12	19	–	+
1207	16	14	70	13	17	–	+
1708	–	–	71	14	15	+	+
1725	–	–	68	11	21	–	+
1739	–	–	61	13	26	–	+
1746	16	–	69	11	20	–	+
1748	16	–	77	9	14	–	+
1749	6	–	79	11	10	–	+
1759	–	–	89	3	8	–	+
1772	–	–	63	11	26	–	+
1780	–	–	79	8	13	+	+
1788	–	–	84	5	11	–	+
1793	–	–	74	10	16	–	+
1795	24	15	77	10	13	–	+
1813	27	25	64	12	24	–	+
1824	5	–	59	12	29	–	+
SS-10693							
105	–	–	76	10	14	–	+
110	–	–	80	6	14	–	+
SS-30000							
45	–	–	77	7	16	–	+
55	–	–	76	6	18	–	+
Average			72	10	18		
Illinoian							
954	12	40	60	21	19	+	+
1706	–	–	60	17	23	–	+
1712	–	–	53	29	18	–	+
1713	7	50	54	24	22	+	+
1714	12	42	59	22	19	+	+
1728	–	–	63	18	19	+	+
1752	–	–	63	17	20	+	+
1787	–	10	62	16	22	–	+
1792	–	–	62	20	18	+	+
1794	–	–	68	15	17	+	+
1817	–	–	62	16	22	+	+
SS-10693							
40	14	42	58	20	22	+	+
70	12	50	54	22	24	+	+
SS-30000							
10	–	–	65	23	12	+	+
20	–	–	61	25	14	+	+
Average			61	20	19		

GEOLOGIC SECTIONS

The numbers enclosed in parentheses are sample numbers. The sections are arranged alphabetically by name.

ABERDEEN SCHOOL SECTION

Measured in creek bank, NW¼ SW¼ SE¼ sec. 31, T. 4 S., R. 4 W., Pike County, Illinois (1963).

	Thickness (feet)
Cretaceous System	
Baylis Formation	
Kiser Creek Member	
4. Sand and clay, tan, massive; contain lenses and zones of dark gray sandy clay and of gray clayey sand (1702)	20.0
Hadley Gravel Member	
3. Sand and gravel, loose, massive; contains cobbles to 4 inches in diameter of chert and quartzite but no igneous rocks (1700).	5.0
2. Pebbles of chert and some quartzite densely iron cemented; contains quartz sand in the cement matrix (1699-A).	0.3
Pennsylvanian System	
Abbott Formation	
1. Shale, gray, platy; weathered to yellow-gray and tan in the uppermost 0.3 foot (1699).	3.0
Total	28.3

BEVERLY SECTION

Measured in road cuts in NW¼ SW¼ SW¼ sec. 16, T. 3 S., R. 5 W., Adams County, Illinois (1963).

Pleistocene Series	
Wisconsinan Stage	
5. Colluvium of silt and sand, leached, massive, tan to brown.	4.0
Cretaceous System	
Baylis Formation	
Kiser Creek Member	
4. Sand, massive, brown and gray, brown mottled, clayey; contains dispersed small chert pebbles in some zones (1735)	6.0
Hadley Gravel Member	
3. Gravel and sand, brown, contains pebbles and cobbles of chert, quartz, and quartzite of several colors but no igneous rocks.	1.0
2. Gravel and sand densely iron cemented, brittle and breaks through the quartz pebbles, dark brown to black (1734).	0.1
Pennsylvanian System	
Abbott Formation	
1. Shale, dark gray, brown and purple, weathered in upper part.	10.0
Total	21.1

ELM GROVE SCHOOL SECTION

Measured in gully in SW¼ NW¼ SE¼ sec. 26, T. 1 N., R. 8 W., Adams County, Illinois (1963).

	Thickness (feet)
Pleistocene Series	
Wisconsinan Stage	
Woodfordian Substage	
Peoria Loess	
7. Loess, weathered, tan-brown.	3.0
Altonian Substage	
Roxana Silt	
6. Loess, sandy, leached, massive, purple-brown.	1.0
Cretaceous System	
Baylis Formation	
Kiser Creek Member	
5. Soil developed in sand; sand, clay, and silt, gray, irregular zones and mottling of tan-brown, weakly cemented with limonite.	2.0
4. Sand, compact, massive, gray-white; contains some clay (1768).	5.0
3. Sand, streaked and mottled with brown, weakly cemented with limonite (1767).	1.5
2. Clay and sand, massive, dark gray, gradational contacts (1766).	1.0
1. Sand, loose and relatively clean, tan with streaks of gray-tan (1765), to bottom of gully.	5.0
Total	18.5

INDEPENDENCE SECTION

Measured in road cut, SW¼ NW¼ SE¼ sec. 18, T. 6 S., R. 3 W., Pike County, Illinois (1963).

	Thickness (feet)
Pleistocene Series	
Wisconsinan Stage	
Woodfordian Substage	
Peoria Loess	
6. Loess, tan to tan-brown, massive, leached; surface soil in top.	8.0
Altonian Substage	
Roxana Silt, Zones II-IV	
5. Loess, pink-tan in upper and lower parts and gray-tan in middle, massive, leached; contacts gradational.	8.0
Roxana Silt, Zone I	
4. Silt, sandy, massive, tan-brown, leached; contains some clay and dispersed streaks of black Mn-Fe.	1.5
Illinoian Stage	
Loveland Silt	
3. Sangamon Soil; silt, sand, and clay, leached, massive with soil structure in upper part, red-brown in upper part grading downward to pinkish tan-brown at base; upper part (B-zone) contains strongly developed streaks and splotches of black Mn-Fe (1825 lower).	3.0
Kansan Stage	
2. Yarmouth Soil; developed on till, brown, tan, and gray, massive, leached; upper part has strongly developed black Mn-Fe streaks and splotches; at top a 3-inch zone of pebbles, partly coated with Mn-Fe, may represent a lag concentrate on the soil (1824 lower).	4.0
Mississippian System	
Burlington Limestone	
1. Afton Soil; chert and clay residuum from weathering of cherty limestone (1823 white clay residuum).	1.0
Total	25.5

PRYOR SCHOOL SECTION

Measured in gully and creek bank, NE¼ NE¼ SE¼ sec. 11, T. 2 N., R. 8 W., Adams County, Illinois (1963).

	Thickness (feet)
Pleistocene Series	
Wisconsinan Stage	
8. Loess, tan, massive, weathered; surface soil at top.	5.0
Illinoian Stage	
7. Till, clayey, massive, tan, mottled with gray in lower part, calcareous in basal part, leached in upper part (1792 lower).	10.0
Petersburg Silt	
6. Silt, gray, inter-zoned with tan in upper part, massive, calcareous; contains nodules of $CaCO_3$ (1791; 1816 at base).	5.0
5. Clay and silt, gray, calcareous, massive with blocky fracture (1790)	2.0
4. Sand, rusty tan, loose.	0.5
3. Sandy silt, tan and gray, massive.	1.0
2. Silt and fine sand, dark gray to purple-gray, platy to blocky, leached; contains organic streaks in upper part (1789 upper; 1815 middle; 1814 lower).	5.0
Kansan Stage	
1. Till, calcareous except in the uppermost part, massive, gray, mottled with tan-brown (1788). Down the creek the till is exposed at a lower level and a sample (1813) was taken from a position 8 feet below the projected top.	4.0
Total	32.5

RICE SCHOOL SECTION

Measured in road cuts and creek banks, SW¼ NW¼ SW¼ sec. 7, T. 3 S., R. 6 W., Adams County, Illinois (1963).

	Thickness (feet)
Cretaceous System (?)	
Baylis Formation (?)	
6. Soil developed in clayey sand, podzolic, red-brown B-zone, discontinuous, platy, iron-cemented zone at base (52).	3.5

	Thickness (feet)
5. Sand, clay and silt, massive, tan, mottled with gray and brown; contains lenses of gray and dark gray to black, sandy, silty clay; dispersed pebbles common in upper part (53; 1684-C; 1685; 1686; 1687).	7.5
Cretaceous System	
Baylis Formation	
Kiser Creek Member	
4. Sand, loose, white to light gray, massive; contains a few dispersed pebbles of chert and quartz in upper part (54; 1684-B).	15.0
3. Sand and clay, massive, gray, streaked with tan; contains a few dispersed chert pebbles (1684-A, at base).	10.0
Hadley Gravel Member	
2. Cobbles and pebbles in a clay matrix; pebbles of chert, tan, gray, and black; quartz, gray and white; and quartzite, pink, gray and white; locally iron-cemented.	0.5
Pennsylvanian System	
Abbott Formation	
1. Shale, weathered, massive, gray and tan.	2.0
Total	38.5

WOODLAND SCHOOL EAST SECTION

Measured in road cut NE¼ NW¼ SE¼, sec. 29, T. 3 S., R. 4 W., Pike County, Illinois (1963).

	Thickness (feet)
Pleistocene Series	
Wisconsinan Stage	
Woodfordian Substage	
Peoria Loess	
9. Loess, tan, compact, leached.	4.0
8. Loess, tan, mottled with gray, massive, leached (1822).	2.0
7. Loess, gray and tan, leached, massive, gradational at top (1821).	1.0
Altonian Substage	
Roxana Silt	
6. Loess, gray-brown, compact, clayey, leached (1820).	2.0
Roxana Silt, Zone I	
5. Silt, sandy, clayey, brown, massive; contains some streaks and splotches of black Mn-Fe staining (1819).	1.5
Cretaceous System	
Baylis Formation	
Kiser Creek Member	
4. Clay, silty and sandy; (Sangamon Soil) gray-brown in lower part becoming purplish dark brown in upper part; upper part heavily impregnated with streaks and splotches of black Mn-Fe (1779; 1818).	1.5
3. Clay, silty and sandy; (Sangamon Soil) tan-brown and brown, massive, gradational top and bottom (1778).	1.0
2. Clay, silty, gray, blocky; contains some sand and sparse granules of chert (1777).	2.5
1. Clay, blocky, dark gray, massive; contains dispersed pebbles of chert and quartz (1776).	1.0
Total	16.5

ZION CHURCH SECTION

Measured in road cuts in SE¼ SE¼ SW¼ sec. 9, T. 3 S., R. 8 W., Adams County, Illinois (1963).

	Thickness (feet)
Pleistocene Series	
Wisconsinan Stage	
Woodfordian Substage	
Peoria Loess	
8. Loess, massive, gray and yellow-tan, calcareous below the surface soil; contains limonite tubules in a zone below surface soil and $CaCO_3$ concretions throughout.	19.0
7. Loess, yellow-tan, massive, weakly calcareous; gradational contacts.	1.5
Altonian Substage	
Roxana Silt	
6. Loess, pinkish-tan to light brown, leached; incipient soil at top and in lower 1 foot; contains Mn-Fe pellets in lower part and a few $CaCO_3$ nodules in middle and upper part.	4.0
Illinoian Stage	
Loveland Silt	
5. Silt, massive, leached, gray-tan; contains some sand and clay; Sangamon Soil at top, B-zone 3-feet thick with Mn-Fe streaks and pellets, blocky to micro-blocky, mottled gray, brown and black.	8.0
Kansan Stage	
4. Till; clay, silt, and sand with sparse dispersed pebbles and cobbles of chert, quartz, quartzite, granite, and other igneous rock types; massive, leached, tan to light brown; Yarmouth Soil at top, strongly developed B-zone 4 feet thick, clayey, blocky, gray and brown with strongly developed Mn-Fe streaks and pellets. At one end of cut a lens of gray silt 3 feet thick occurs on top of the till.	25.0
3. Till, calcareous, gray and tan, massive; consists of clay, silt, and sand with sparse pebbles, cobbles, and boulders (1746).	5.0
2. Silt, calcareous, gray with tan-brown streaks, massive but with indistinct color zonation; contains a few dispersed small pebbles and sparse fossil snail shells; upper contact with till is sharp but irregular (1745).	6.0
Nebraskan Stage	
1. Gravel, sand, and silt, yellow-tan to red-brown, indistinctly bedded; pebbles include chert, quartz, quartzite, weathered granite, and other igneous rocks (1743); Afton Soil at top, strongly developed, clayey, red-brown B-zone at top (1744) in sharp contact with calcareous silts above: base of gravel not exposed.	4.0
Total	72.5

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